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Dollinger et al.

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[54] **CARBON BLACK REACTOR WITH AXIAL FLOW BURNER**

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Related U.S. Application Data

[62] Division of Ser. No. 711,443, Aug. 4, 1976, Pat. No. 4,077,761.

[51] **Int. Cl.**[2] **C01B 49/00**

[52] **U.S. Cl.** **23/259.5**; 431/8; 423/457

[58] **Field of Search** 23/259.5; 431/8; 423/456, 457

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,087,796	4/1963	Lathan, Jr. et al.	23/259.5
3,256,066	6/1966	Higgins	23/259.5
3,669,628	6/1972	Lathan, Jr. et al.	23/259.5

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[57] **ABSTRACT**

An improved burner for combusting gaseous fuel and oxidant gas is provided in which the fuel and oxidant gas are premixed prior to combustion by the turbulence generated by flowing the gases through a mixing zone containing a centrally disposed flow disrupting bluff body positioned in the oxidant gas stream upstream from the point of fuel injection, and a peripheral flow disrupting bluff body disposed at the periphery of the mixing zone. The burner finds particular utility in combination with other elements of a furnace-type carbon black reactor. This abstract is not to be construed in any way to define or limit the invention set forth below.

4 Claims, 9 Drawing Figures

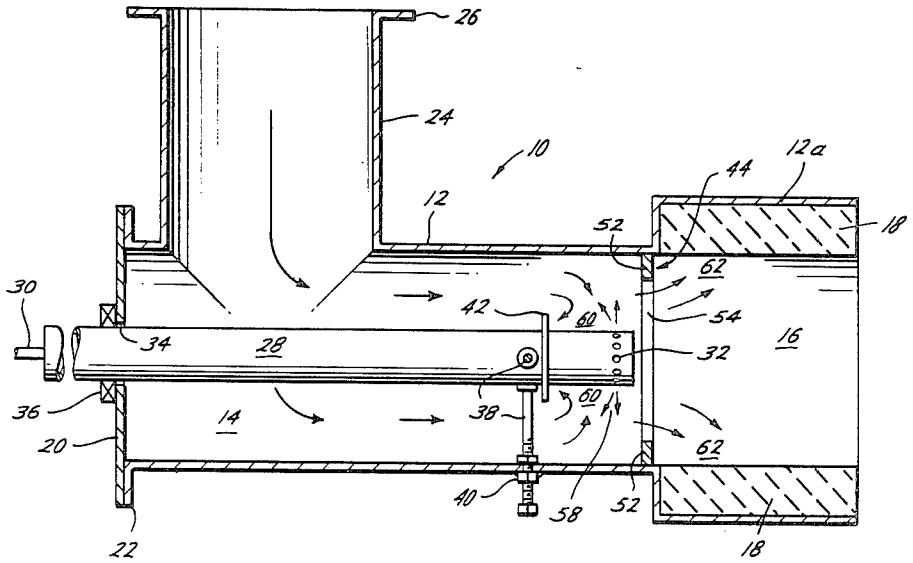


Fig. 1

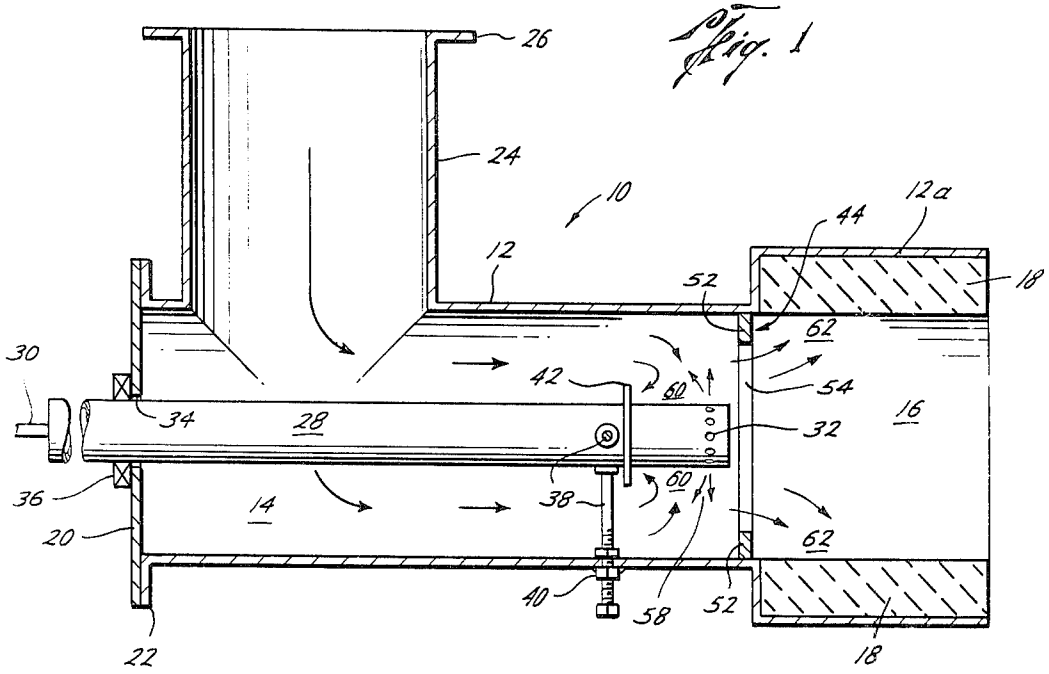


Fig. 2

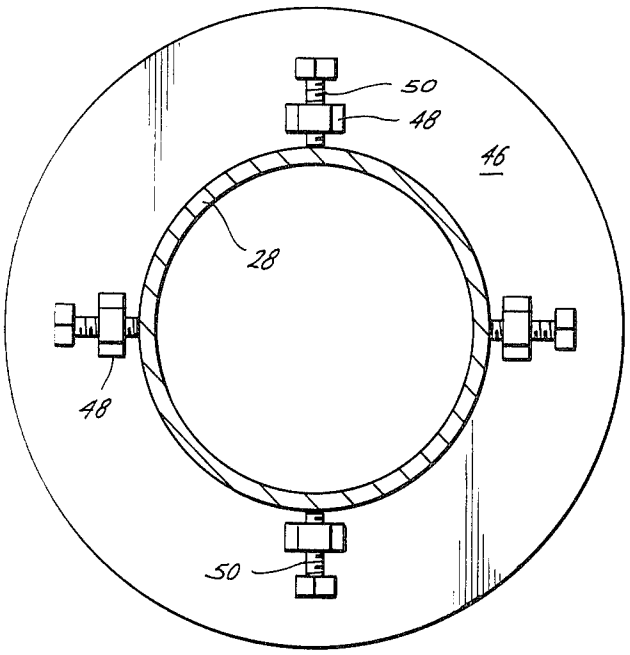


Fig. 3

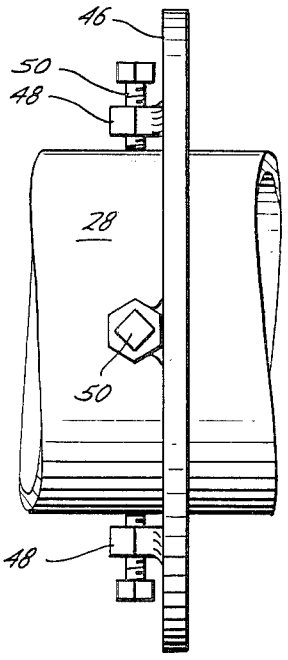


Fig. 4

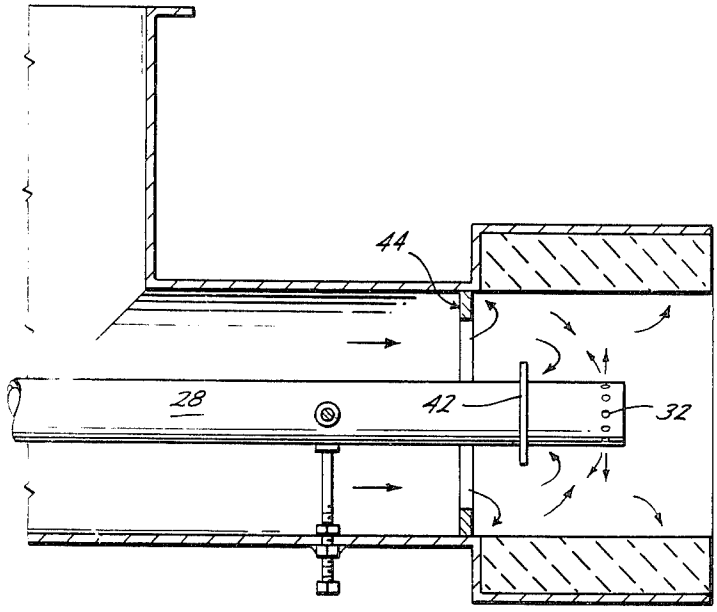


Fig. 5

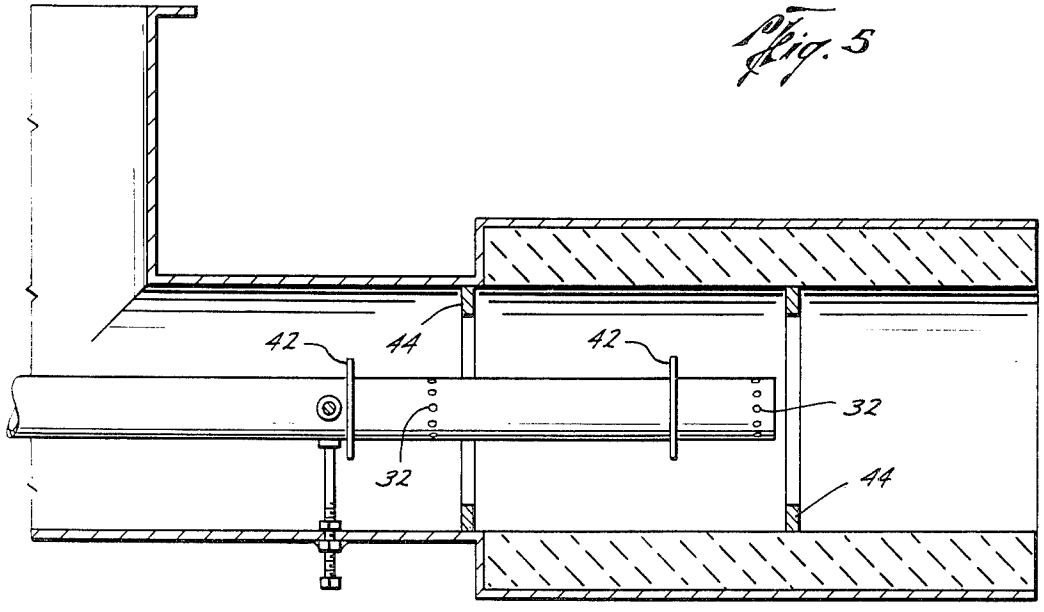


Fig. 6

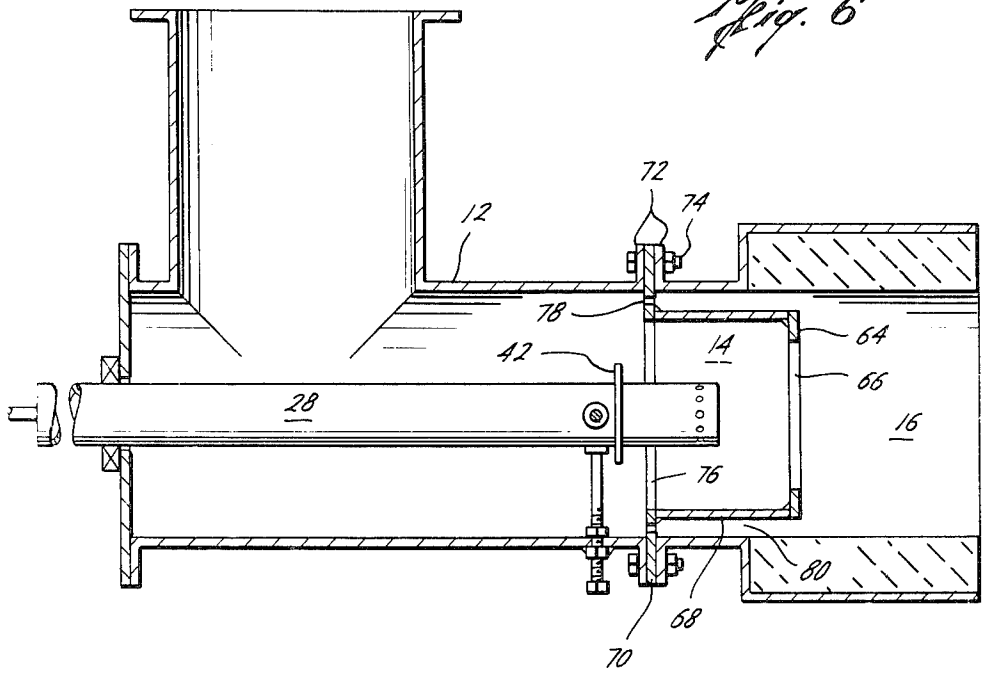


Fig. 7

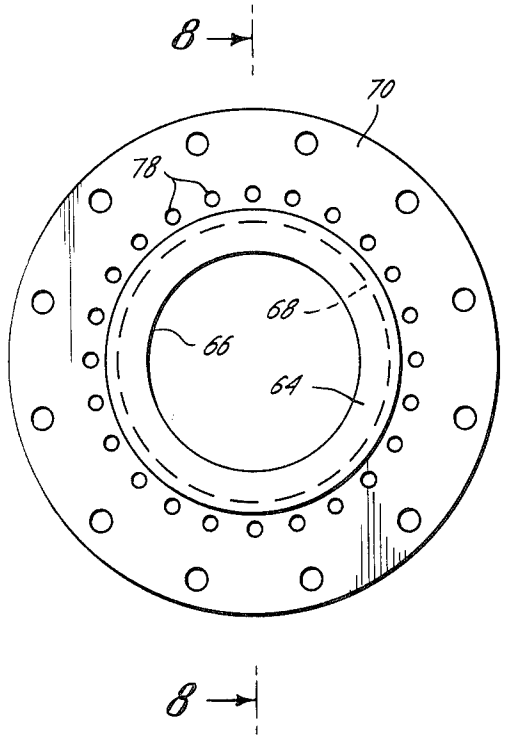
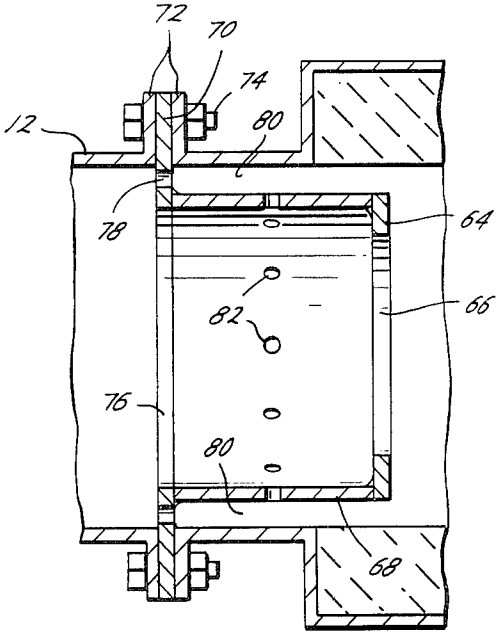


Fig. 8



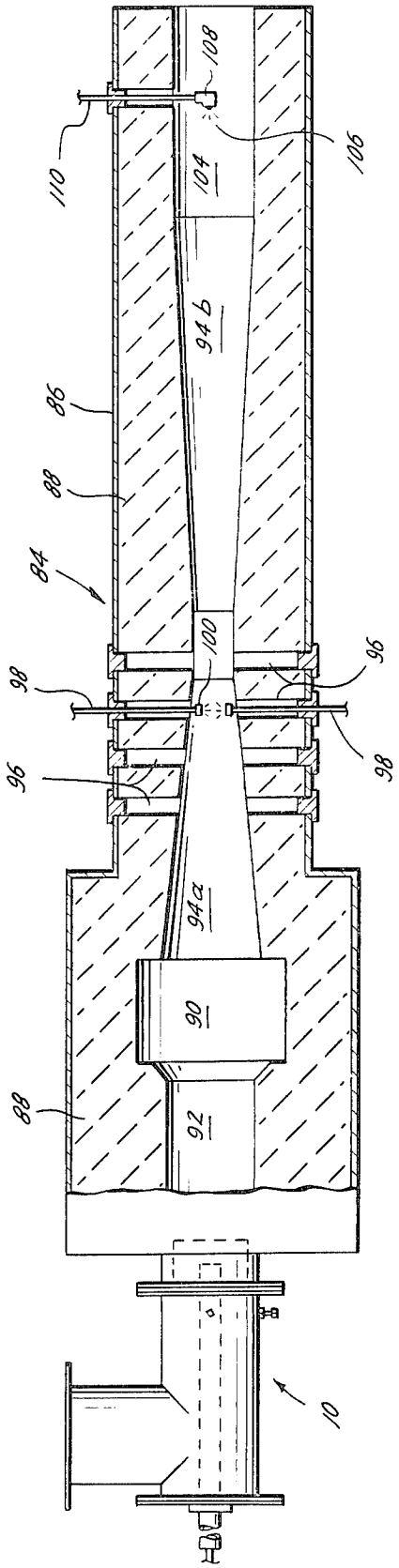


Fig. 9

CARBON BLACK REACTOR WITH AXIAL FLOW BURNER

BACKGROUND OF THE INVENTION

This application is a division of co-pending application Ser. No. 711,443 filed Aug. 4, 1976 now Pat. No. 4,077,761 issued Mar. 7, 1978. This invention relates to an improved method and apparatus for gaseous fuel combustion, useful in many applications. This invention also relates to the production of furnace-type carbon black, utilizing a hot stream of gases produced by the burner apparatus of the invention, and injecting into the hot gases a suitable feedstock hydrocarbon under proper flow conditions. More particularly, the invention relates to an improved method and apparatus for producing carbon black whereby heat is generated in an especially advantageous manner and in which the conditions of flow of the hot gases and the manner of introduction of the hydrocarbon feedstock are such as to allow a highly desirable versatility in the production of a wide range of particle size and structure of furnace carbon blacks demanded by the market.

Carbon blacks are produced by several processes, the most common being the channel process, the thermal process and the furnace process. The historic channel process produces carbon black by the impingement of flames of gaseous fuel on channel irons in an environment of air deficiency. Because of the price and supply of natural gas, the process is much less used than formerly. The thermal process is a cyclic process which contacts hydrocarbon gases cyclically with hot checkerwork, and produces a coarse carbon black of low structure. The thermal blacks are used largely as fillers where a minimum of reinforcement of rubber is required. The furnace process is more economical than these two. In the furnace process, a hydrocarbon fuel is burned in a closed vessel, usually refractory-lined, to produce hot combustion product gases and another hydrocarbon stream is injected into the hot gases of combustion to be carbonized and form the product. The second hydrocarbon stream from which the carbon black is made is commonly referred to as the "make" or "feedstock" stream.

In the furnace processes, the feedstock may be a gas, but for both economic and quality reasons, an aromatic hydrocarbon oil is the material of choice. The fuel may be a gas or an oil, but where gas is available and is economical, it is the fuel of choice.

Oil furnace carbon black reactors are generally of circular cross section and elongate configuration, and are functionally composed of several zones. The first zone is the zone of combustion in which fuel and air are burned to produce hot combustion product gases which supply heat for the process. This heat-supplying combustion process is of critical importance, because the temperature of the combustion products determines to a great degree the quality of the carbon black produced. In addition, a combustion system which results in uneven burning may cause marked and harmful temperature gradients within a reactor, thus subjecting one portion of the feedstock to a different temperature than another portion of the feedstock. Unburnt fragments of a non-aromatic fuel may also interfere with the kinetics of carbonization of the aromatic oil. It is also important that the hot gases leaving the zone of combustion flow in such a manner that the aerodynamic pattern is favorable to the formation of the quality of carbon black desired.

The most efficient burners heretofore known for carbon black reactors utilized vortex or tangential flow of the gases in order to achieve sufficient mixing of the air and fuel gas for complete, uniform combustion. However, a characteristic of such a burner is that the hot combustion products continue to have a vortex, or tangential flow, pattern as they exit from the burner and enter the carbon black reactor proper. This is less desirable for the production of certain types of carbon black than is axial or linear flow of the reaction products. On the other hand, linear flow of the combustion product gases, where desired, has heretofore been achieved only through burners which are less efficient and advantageous than either vortex burners or the burners of the present invention. Therefore, combination of the burner of the present invention, with the other elements of a carbon black reactor, as hereinafter described, provides for highly efficient combustion of the fuel gas and air while at the same time producing linear or axial flow of the combustion products as they are fed to the reaction zone of the carbon black reactor.

The second zone in the reactor is the zone of reaction, in which the oil is dehydrogenated, nucleated as carbon, accreted into chains or clusters to form what is known as structure, and formed into the ultimate particle size it will attain. In the electron microscope, carbon black typically appears as more or less spheroidally-shaped particles fused together in clusters or chains. The degree of such clustering or chaining is the degree of structure of the material. When compounded into rubber formulations, blacks with higher structure produce stiffer compounds, and may be compounded with higher proportions of extender oil, which is an economic advantage. In some degree, higher structure contributes to the resistance to abrasion of rubber used in treads of automobile tires. However, for some uses in rubber, lower levels of structure are required. Therefore, it is necessary that the manufacturer of carbon black be able to make a range of structure levels to meet the market demands.

The third zone of the carbon black process is the quench zone in which the reaction is rapidly cooled by water injection. After the formation of the carbon, prolonged exposure to high heat damages the properties of the rubber formulations made with the product. The choice of the position of the water stream which quenches the reaction may be properly made by those skilled in the art of carbon black manufacture. If quenched too soon, the process will produce an oily carbon; if quenched too late, the process will produce a black with a damaged surface.

OBJECTS OF THE INVENTION

One object of the invention is to provide a novel burner apparatus which produces a flame of high temperature and high heat release per unit of volume. Another object is to provide a burner producing a stable flame front without flame contact with a flame holder. Another object of the invention is to provide apparatus for producing a stable, intense flame without introducing fuel or oxidant gas tangentially to form a vortex and for obtaining the quality of combustion attainable by tangential or vortex flow, without utilizing tangential flow or the ponderous equipment which its use requires.

An important object of the invention is to provide a combination of a uniquely efficient non-tangential

burner of great flexibility with a tapered carbon black reactor, including means for radial injection of carbon black feedstock into the axially flowing combustion products in the reactor.

DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the invention will become apparent from the specification drawings and claims. In the accompanying drawings, in which like numerals indicate like parts:

FIG. 1 is a view in vertical section illustrating, somewhat diagrammatically, a preferred embodiment of the burner according to the present invention;

FIG. 2 is a view in front elevation of the central bluff body of the burner of FIG. 1;

FIG. 3 is a view in side elevation of the central bluff body of FIG. 2;

FIG. 4 is a view in vertical section illustrating diagrammatically the function of the burner of FIG. 1 when the central bluff body is located upstream of the annular bluff body;

FIG. 5 is a view in vertical section illustrating diagrammatically an alternate embodiment of the burner, having a plurality of central and annular bluff bodies;

FIG. 6 is a view in vertical section illustrating the preferred commercial embodiment of the burner;

FIG. 7 is a view in front elevation of the peripheral bluff body of FIG. 6;

FIG. 8 is a view in vertical section of the peripheral bluff body of FIG. 7, taken along lines 8—8 of FIG. 7; and

FIG. 9 is a view in side elevation of a furnace-type carbon black reactor in combination with the burner of FIG. 6.

DESCRIPTION OF THE INVENTION

Referring to FIG. 1 there is shown in vertical section a burner **10** constructed in accordance with the present invention. It includes a cylindrical housing **12**, preferably of metal, defining a generally cylindrical mixing zone **14**, in which the oxidant gas and fuel are premixed, and a combustion zone **16** in which the gases are burned to release heat. The housing **12** is of enlarged diameter as shown in **12*a*** in the combustion zone area and is lined with refractory material **18** to tolerate high temperatures produced by the burner. A plate **20** attached to housing **12** by flange **22** closes the upstream end of the mixing zone **14**.

Means for introducing oxidant gas, preferably air, into the mixing zone **14** comprise a duct **24** opening through the housing **12** and having a flange **26** for attachment to a supply of oxidant gas, preferably air. Air supplied through duct **24** will flow axially through the mixing zone **14**, where it is admixed with gaseous fuel as described hereinbelow, and thence into the combustion zone **16** for combustion.

Means for introducing gaseous fuel into the air flowing axially in the mixing zone **14** preferably comprise a fuel supply tube **28** connected to fuel supply **30** and having a plurality of orifices **32** for injecting fuel gas into the flowing oxidant gas at a point downstream from the air supply duct **24**. The fuel supply tube **28** is centered about the longitudinal axis of the mixing zone **14** in housing **12** and extends through a central opening **34** in the end plate **20**. Tube **28** is manually adjustable along the longitudinal axis of the mixing zone **14**, a suitable packing gland **36** permitting such axial adjustment of the fuel supply tube while retaining a seal to prevent escape of gas from the burner.

Means for centering the supply tube in the mixing zone include three adjustment bolts **38** which extend through nuts **40** mounted on the burner housing **12**, and through openings in the housing, to engage the outside surface of the supply tube **28**. One bolt **38** is provided for vertical adjustment of the supply tube **28** and two additional bolts disposed on opposite sides of the tube **28** permit horizontal adjustment.

Means are provided for admixing the air and fuel in the mixing zone **14** prior to their admission into the combustion zone **16**. These mixers comprise a central bluff body **42** centered about the longitudinal axis of the mixing zone **14** and extending radially outwardly and a peripheral bluff body **44** spaced axially from the central bluff body and disposed about the periphery of the mixing zone **14**, extending radially inwardly from the periphery toward the central longitudinal axis.

By the term "bluff body" as used herein is meant a non-streamlined, flow-interrupting body which is preferably, although not necessarily, of square-edged generally circular configuration and which causes mixing turbulence in the gases flowing in the burner.

As shown in greater detail in FIGS. 2 and 3, the central bluff body **42** preferably comprises a square cornered annular plate **46** mounted on the fuel supply tube **28** upstream from the orifices **32**. The plate has an inside diameter approximately equal to the outside diameter of the gas supply tube **28** and an outside diameter substantially less than the diameter of the mixing zone **14**, whereby oxidant gas may flow freely through the annular space defined by the inside diameter of the burner body **12** and the outside diameter of the plate **46**.

Means are provided for mounting the plate **46** on the fuel supply tube **28** and for permitting its longitudinal adjustment with respect to orifices **32**. Such mounting and adjustment means preferably comprise a plurality of nuts **48** welded edgewise to the plate **42** for receiving bolts **50** which may be selectively tightened to rigidly mount the plate **46** on the supply tube **28** and loosened to permit plate **46** to be adjusted longitudinally of the supply tube **28**, with respect to the fuel orifices **32**.

The peripheral bluff body **44** comprises a square-edged annular plate **52** having an outside diameter approximately equal to the diameter of the mixing zone **14** and a central opening **54** which permits the mixture of fuel and air to flow therethrough into the combustion zone **16**. The plate **52** may be made of metal or other suitable material capable of withstanding high temperatures.

In operation of the burner, oxidant gas, preferably air, is supplied through duct **24**, as indicated by arrows **56** and flows axially through the mixing zone **14** of the burner. Gaseous fuel, preferably natural gas, is supplied through tube **28** and exits from the orifices **32** in a generally radial direction, as indicated by the arrow **58**. A mixing turbulence between the air and fuel is created, as indicated at **60**, as the air flows around the central bluff body **42**. An additional mixing turbulence, as indicated at **62**, is caused as the air and fuel flow around the peripheral bluff body **44**. Combustion takes place downstream of the peripheral bluff body **42** in the combustion zone **16** and remains stable, without the necessity for a flame holder.

As will be understood by those skilled in the art, various adjustments in the size, shape and relative positions of the central and peripheral bluff bodies, and of

the position of the fuel orifices 32 with respect to the bluff bodies, may be necessary in order to provide stable, complete combustion under the various conditions of air to fuel ratios, BTU content of the fuel, oxygen content of the oxidant gas, air and fuel supply rates, pressures, temperatures, etc. Depending upon any particular combination of variables present, some degree of experimentation may be required in order to produce optimum results, and it is for this reason that the bluff body 42 is preferably made adjustable with respect to the gas orifices 32, and the assembly comprising the gas tube 28 with its holes 32 and the attached bluff body 42 is axially adjustable with respect to the peripheral bluff body 44.

While the central bluff body 42 is always maintained upstream from the gas supply orifices 32, the gas supply orifices and/or the central bluff body 42 may be positioned either upstream of the peripheral bluff body 44 (as indicated in FIG. 1) or downstream thereof (as indicated schematically in FIG. 4) in order to maintain optimum combustion. Also, it may be desirable to use a plurality of central bluff bodies 42 and peripheral bluff bodies 44 as illustrated in FIG. 5. In this event, it is desirable to provide a separate set of gas supply orifices for each of the central bluff bodies.

It has been found that positioning the gas supply orifices 32 and central bluff body 42 upstream of the peripheral bluff body 42 is preferable where the supply air is preheated to about 350° F or higher. However, where ambient temperature supply air is utilized, more stable combustion is generally achieved by positioning the central bluff body and gas supply orifices downstream of the peripheral bluff body, as illustrated in FIG. 4.

Combustion takes place downstream of the peripheral body 44 which does not function as a flame holder; however, since it is subjected to radiant heat, it is preferably made of heat resistant material, as for example, heat resistant alloy. As hereinafter explained, a design may be used in which the peripheral bluff body is cooled by a small flow of combustion air.

In the preferred commercial embodiment of the burner, illustrated in FIG. 6 of the peripheral bluff body is formed of metal plate and cooling means are provided.

As shown in greater detail in FIG. 6 through 8, the peripheral bluff body 44 of the preferred commercial embodiment comprises an annular plate 64, preferably of metal, of slightly less outside diameter than the diameter of the mixing zone 14 and having a sufficient central opening 66 to permit the mixture of oxidant gas and fuel to flow the rethrough into the combustion zone 16. The annular plate 64 is centered in the mixing zone by means of a cylindrical support member 68 mounted on an annular flange 70 which fits between flanges 72 provided in the burner body 12. Bolts 74 extend through aligned openings in the flanges 70 and 72.

Mounting flange 70 has an inside diameter approximately equal to that of the supporting cylinder 68 for annular plate 64, thereby providing a central opening 76 through the flange 70 equal in diameter to the inside diameter of cylinder 68, through which opening 76 the air-fuel mixture may flow toward the annular plate 64, and through which the fuel supply tube 28 may extend into the cylinder 68, as illustrated in FIG. 6. A plurality of openings 78 are provided about the periphery of mounting flange 70 whereby supply air may circulate through the annular space 80 between the inside diameter of the burner body 12 and the outer surface of the support cylinder 68, thereby cooling the surface of the cylinder 68, which acts as a heat sink for the annular plate 64. If desired, a plurality of openings 82 may also be provided in the body of the supporting cylinder 68 to provide for additional gas circulation into the annular space 80.

A burner constructed substantially in accordance with FIG. 6, but lacking the central bluff body 42, has been commercially used for some period of time in connection with carbon black manufacture. However, this burner was generally unsatisfactory in that the distribution of temperatures in the combustion zone 16, from highest temperature to lowest in the zone, was too wide, indicating incomplete mixing of the supply air and fuel gas prior to combustion and also indicating incomplete combustion of the fuel. Also, under certain flow conditions, the burner was subject to severe and potentially destructive sonic vibrations. However, upon modification of the burner by addition of the central bluff body 42, combustion temperatures in zone 16 became more uniform, fuel combustion more complete and the destructive sonic vibrations were eliminated.

While the burner of the present invention may find utility in a variety of commercial and industrial applications, it is particularly useful as the burner section of a furnace-type carbon black reactor for the reasons stated in the Background of the Invention section above.

Referring now to FIG. 9, there is shown a burner 10 according to the present invention in combination with a carbon black reactor 84 including an outer housing 86, preferably of metal, lined with a refractory material 88 of varying thickness to provide a central longitudinal tunnel 90 of generally circular cross-sectional configuration and varying diameter. The reactor tunnel 90 includes a combustion zone 92 in which the admixed air and fuel gas from the burner 10 are combusted to produce high temperature combustion products which flow axially through the combustion zone to a reaction zone 94 comprising a convergent section 94*a* and divergent section 94*b*. A plurality of ports 96 extend through the housing 86 and refractory 88 of the reactor to provide access for feedstock supply tubes 98 through which hydrocarbon feedstock, preferably oil, is injected radially from nozzles 100 into the hot flowing combustion product gases in the convergent section 94*a* of the reactor. Although two feedstock injection tubes 98 are illustrated, any desired number may be utilized, disposed radially about the reactor. The feedstock injection tubes are adjustable radially with respect to the longitudinal axis of the reactor 84 so that the degree of radial penetration of the injection nozzles 100 into the reactor zone of the reactor may be controlled as desired. Also, a plurality of feedstock supply ports 96 are provided, spaced axially along the reactor, so that the feedstock supply may be selectively positioned as desired along the axis of the reactor. Feedstock injection ports not in use are closed by plugs 102.

The pyrolysis reaction commenced as the atomized feedstock oil is injected into the axially flowing hot gases from the burner 10 by nozzles 100 continue as the combustion gases and oil droplets move through the convergent and divergent portions of the reaction zone 94 and into the quench zone 104 in which the reactions are quenched by quench water 106 supplied through nozzle 108 from pipe 110. The resulting mixture of gases and carbon black product then exits the reactor to a suitable collection system (not shown) downstream, in

which the product is separated from the combustion product gases and steam and is subsequently pelletized and packaged.

The foregoing disclosure and description of the invention and of the preferred embodiments is illustrative and explanatory thereof only and various changes may be made in the size, shape and materials of construction without departing from the spirit of the invention.

What is claimed is:

1. An apparatus comprising:

a carbon black reactor lined with refractory material of varying thickness defining a longitudinal tunnel of generally circular cross-sectional configuration and varying diameter,

said tunnel comprising combustion, reaction and quench zones;

a burner for supplying admixed oxidant gas and gaseous fuel to the combustion zone of said carbon black reactor for combustion therein to provide hot combustion product gases for flowing through said reactor to produce carbon black, said burner comprising,

a housing defining a generally cylindrical mixing zone having a central axis extending longitudinally therethrough,

said mixing zone being in open contiguous axial alignment with the combustion zone of said carbon black reactor,

means for introducing oxidant gas into said mixing zone to flow axially therethrough,

means for introducing gaseous fuel into said mixing zone at a point downstream of said oxidant gas introduction means, whereby said fuel is released into said flowing oxidant gas,

mixer means in said mixing zone for admixing said oxidant gas and fuel, said mixer means comprising,

a central bluff body centered about the axis of said mixing zone and extending radially outwardly from said axis, and

a peripheral bluff body disposed at the periphery of said mixing zone and extending radially inwardly toward said axis,

said central and peripheral bluff bodies being spaced axially from each other;

means for introducing liquid hydrocarbon feedstock radially into said reactor zone of said carbon black reactor; and

means for introducing quench water into said quench zone of said carbon black reactor.

2. The apparatus according to claim 1 wherein said reaction zone includes convergent and divergent portions.

3. The apparatus according to claim 1 wherein said means for radially injecting said feedstock into said reaction zone are adjustable both radially and axially with respect to said combustion zone.

4. The apparatus according to claim 1 wherein a plurality of central bluff bodies and a plurality of peripheral bluff bodies are provided spaced axially along said mixing zone.

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